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Steve —

FvH asked me to drop by this report on operating experience w/ dry storage of magnox fuel.

JHT

RECEIVED
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J. KASS

Nuclear Electric

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Text

Report on Dry Storage of Magnox type fuel as discussed.

Norm Haines

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OPERATING EXPERIENCE OF VAULT TYPE DRY STORAGE AND ITS RELEVANCE TO FUTURE STORAGE NEEDS

Paper prepared to the Specialist Workshop on Techniques for the Dry Storage of Spent Fuel Elements

Nuclear Energy Agency Organisation for Economic Cooperation and Development

Mr E O Maxwell
Central Electricity Generatin Board

and

Mr D Deacon
GEC Energy Systems Limited

May 1982

OPERATING EXPERIENCE OF VAULT TYPE DRY STORAGE AND IT'S RELEVANCE TO FUTURE STORAGE NEEDS

1 INTRODUCTION

For many years irradiated fuel has almost universally been stored under water prior to it being reprocessed. Water provides a ready heat sink for the decay heat removal and also provides shielding against the highly active fuel. The original requirements for storage were short term, the fuel being stored until the decay heat output and radiation levels had decayed sufficiently to allow transportation in suitable flasks to the reprocessing facility. (Decay periods in the order of 90-150 days.)

There is now an increasing requirement to store fuel for very much longer periods. Periods up to 100 years are being considered. It cannot be denied that to date there is far greater experience in the pond system of irradiated fuel storage than any other form of storage. However, it is necessary to take into account the fact that the early design of pond installations took place before the design parameters for irradiated fuel storage facilities became so exacting. It is not suggested that pond type installations cannot be built to the necessary safety standards but rather that when considered against the latest design specifications other forms of storage are likely to give better overall optimisation of requirements.

In addition to the considerable experience in the design and operation of dry storage in the UK it is also necessary to highlight the fact that fuel has been handled 'dry' almost without exception since the advent of nuclear power in Great Britain. This tremendous wealth of design, manufacture and operating experience of dry fuel handling machinery has enabled us to confidently produce generic designs of dry fuel handling machines for handling irradiated light water reactor fuel between reactor storage pools and the dry storage facilities. This is very relevant, no matter whether these be vault or cask type stores located at the reactor or away from the reactor.

2 WYLFA CO_2 DRY STORE CELLS, DESIGNATED CELLS 1, 2 AND 3

The concept of dry storage of irradiated fuel is not new. The Wylfa magnox power station situated in North Wales was designed with three dry storage modules when construction commenced some 18 years ago. These dry stores each have a capacity of 83 tonnes and they are cooled by completely passive means. The irradiated fuel elements discharged on load from a reactor by a fuelling

Machine are stacked 12 high in tubes connected at the upper ends to a vessel containing the loading chute. This chute distributes the fuel from the central access standpipe to the tubes. The atmosphere within the tubes is CO_2 at a nominal pressure of 3 psig and a purity of at least 99.8%. The primary mode of decay heat removal from the fuel is by radiation to the tube wall, conduction through the tube and then by natural thermosyphon air cooling.

A CO_2 atmosphere was chosen, as the limiting temperature for both uranium and magnox in CO_2 is about 600°C, whereas in air, the limiting temperature for uranium oxidation is 250°C. Very low concentrations of air, eg, 0.2% could result in the oxidation of exposed uranium, if it were present, at a rate approaching that of 100% air. Thus, a very high CO_2 purity is required in order to allow the cells to accept fuel direct from the reactors.

The operation and performance of these cells has been very satisfactory since they first came into operational service some 10 years ago.

3 OPERATIONAL EXPERIENCE WITH CELLS 1, 2 AND 3

3.1 The completely passive cooling regime has proved to be completely reliable.

3.2 The manning requirement has been limited to the personnel necessary to carry out the CO_2 purity checks. Frequency of checks, approximately once per week.

3.3 During operations to date many various heat load conditions from part load to full load have been experienced and the satisfactory performance of the store has been demonstrated. No detectable effects in store performance due to wind conditions have been found although the winds can gust at up to 130 KPH in this very exposed location.

3.4 The materials of construction of the store have been demonstrated to have an adequate life, even though these cells have their natural convection air inlet within 100 metres of the sea.

3.5 The Cells 1, 2 and 3 do not contribute any significant amount to the total station man-Sv commitment.

3.6 During testing and operation of these stores at Wylfa it has been demonstrated that the maximum measured fuel element temperatures are slightly lower than those predicted theoretically during the design process.

3.7 Post Irradiation Examination (PIE) of fuel having a dwell time of up to 4 years has shown it to be in pristine condition and indeed licencing approval has been obtained to allow this fuel to be reloaded into the reactor if necessary for further irradiation.

3.8 However, Cells 1, 2 and 3 had one drawback, ie, capacity. Generally, the CEGB's magnox station with cooling ponds have an average storage capacity of about 1 Te/MW of station output whereas at Wylfa it was about 0.3 Te/MW. Also Wylfa's throughput of irradiated fuel is about one quarter of the total arisings of the CEGB's magnox stations. Experience showed this capacity to be inadequate in the event of limitations in flask traffic or throughput at BNFL's, Sellafield reprocessing plant.

4 THE WORLD'S FIRST COMMERCIAL AIR FILLED VAULT DRY STORE

Because of the above limitation, and Wylfa being the only station where fuel is handled and stored dry prior to loading into transport flasks, it was decided in 1976 to increase on site storage of irradiated fuel. Bearing in mind that the existing CO_2 cells can accept freshly irradiated fuel direct from the reactors, these cells could be used as a decay store such that an air environment could be used for additional storage without exceeding fuel limiting temperatures, as discussed below:

4.1 Design and Safety Criteria

Air was chosen as the environment for the fuel in order to eliminate the requirement for a store liner to seal to absolute standards. Although the construction of the liner is to high standards, and it is demonstrated to be leak tight on completion, it is very difficult to demonstrate that over very long periods the structure remains absolutely leak tight. The atmosphere within the store is maintained at a slight depression by means of an exhauster system discharging to atmosphere via a comprehensive filter system provided with generous redundancy. Should a slight leak develop in the store envelope it is readily recognised by a reduction in the store depression and remedial action can be taken. Obviously any leakage that does occur will always be into the cell and not contamination outwards.

The uranium ignition limiting temperatures of 250°C for saturated air and 300°C for dry air were set after consideration of existing experimental data. This data demonstrates that for irradiated uranium, the oxidation rate for the zone of highest irradiated swollen uranium at 250°C, is well below the characteristic of delayed ignition, and to date, no delayed ignition of irradiated fuel sections are known below these temperatures. In the absence of exposed uranium, the temperature limit would be set by the ignition of magnox, ie., 610°C in saturated air and 625°C in dry air.

Also to inhibit the formation of uranium hydride which might cause spontaneous ignition in the event of fuel damage during handling, it is necessary to prevent condensation within the storage cell. This is achieved by means of a dehumidification plant.

Thus, the following are the fuel design criteria for the air filled store:

a the maximum fuel element temperature under normal operating conditions will not exceed 150°C

b the maximum fuel element temperature under the worst credible fault conditions will not exceed 200°C

c there is no condensation under the lowest credible temperature conditions (25°C)

d during normal operating conditions the moisture level will be less than 30,000 vppm water or 50% relative humidity, whichever is the lesser.

Thus the margins before uranium ignition could occur is at least 50°C and for magnox ignition it is at least 400°C. There are no known magnox ignition incidents as a result of uranium ignition.

4.2 Design Principles

It was decided to build two storage cells each with a capacity of 350 Te uranium. As it would be impossible to guarantee that the cell storage chamber could remain absolutely sealed throughout its life the atmosphere of the store should be subatmospheric to prevent outleakage of any contamination as previously described.

Natural convection was chosen for cooling the fuel within the store. An inherent advantage of natural convection cooling is that the cooling air does not need to be guided to the hot fu l. By careful design, it can be arranged that the fuel raws cooling air according to its needs. The higher the heat output from the fuel, the greater the bouyancy head and hence the greater the cooling flow. The bulk heated air is then recirculated and its heat removed by a conventional fan and heat exchanger system embodying adequate redundancy. Five such fan/heat exchanger units are provided of which four are used for normal operation. When freshly irradiated fuel is removed from the reactor (decay heat typically in the order of 1 KW) it is stored in the existing CO_2 cooled dry store cells for at least 150 days so that the decay heat can reduce to a level acceptable to the air cooled dry store. The heat output from a peak rated fuel element in the reactor, having decayed for 150 days is approximately 46 watts including a 20% margin. The gamma radiation to thermal output ratio was thoroughly investigated for fuels under various burn-up and decay conditions. Knowing this ratio for maximum burn-up, it was possible to arrive at a value for gamma output corresponding to the maximum permissible value for a thermal output of 46 watts. Making allowances for drift, and calibration of instrumentation, the maximum rating of an element that can enter the store is less than 60 watts. Thus, as it is desired to set a limit on the maximum possible thermal rating of fuel elements for storage, it is only necessary to monitor the gamma activity of the elements. This is achieved by equipping the transfer machine (which transfers fuel from the CO_2 stores to the air stores) with 3 gamma detectors, to satisfy a high level interlock requirement, that monitor [illegible] the gamma dose rate corresponding to the heat output of the fuel. The gamma dose rate chosen allows the detectors to be set to reject fuel which has a higher output than the predetermined limit. The allowable heat rating of the fuel in the store and thus the temperature limitations are in this way satisfied.

The equipment within the store is designed to eliminate the need for maintenance. Such components that do require maintenance are provided with maintenance equipment designed to minimise radiological hazards in the maintenance areas.

The irradiated fuel is adequately shielded during the transfer operations from the CO_2 to the air cells and in the air cells by the required thickness of reinforced concrete.

Equipment and components are designed to prevent fuel element damage at all stages of handling and storage. The design is assessed for hazards, the severity of the hazard determines the degree of protection required, ie., integrity of interlocking. Any plant capable of shearing a fuel element, is, in addition, fitted with torque limiting devices and provision made to minimise the damage in the event of a fuel element being dropped. All electrical and cooling water supplies are duplicated and on segregated routes.

5 LAYOUT OF PLANT

5.1 Limitation of Physical Parameters for the Wylfa Store

An important aspect of the construction of the air cooled fuel stores at Wylfa was that the design and construction had to be closely integrated with the existing power station. The design and construction of the new stores was successfully carried out without any interruption to the operation of the existing power station although they are closely associated structurally and operationally with the existing plant.

The requirement to ensure this compatibility with the existing structures has led to an embodiment of the principles outlined above which is less than optimum in some aspects of the store itself.

The Wylfa Reactors are the largest magnox reactors that have been constructed (2 x 590 mw). To move the fuelling machines (150 Te) around the charge face by means of a conventional crane arrangement involving such a large span would have required significantly more expensive structural requirements than a remotely operated transporter system, and so this is the system that was adopted when the station was originally conceived. This transporter system gave a particular problem when it became necessary to choose the site for the new store (Cell 4) and also it had a significant effect on the resultant envelope for Cell 5. The working area for the fuelling machinery and transporters is shown diagramatically in Figure 5. During the initial construction of the station, the working area was suitably reinforced to enable it to accommodate

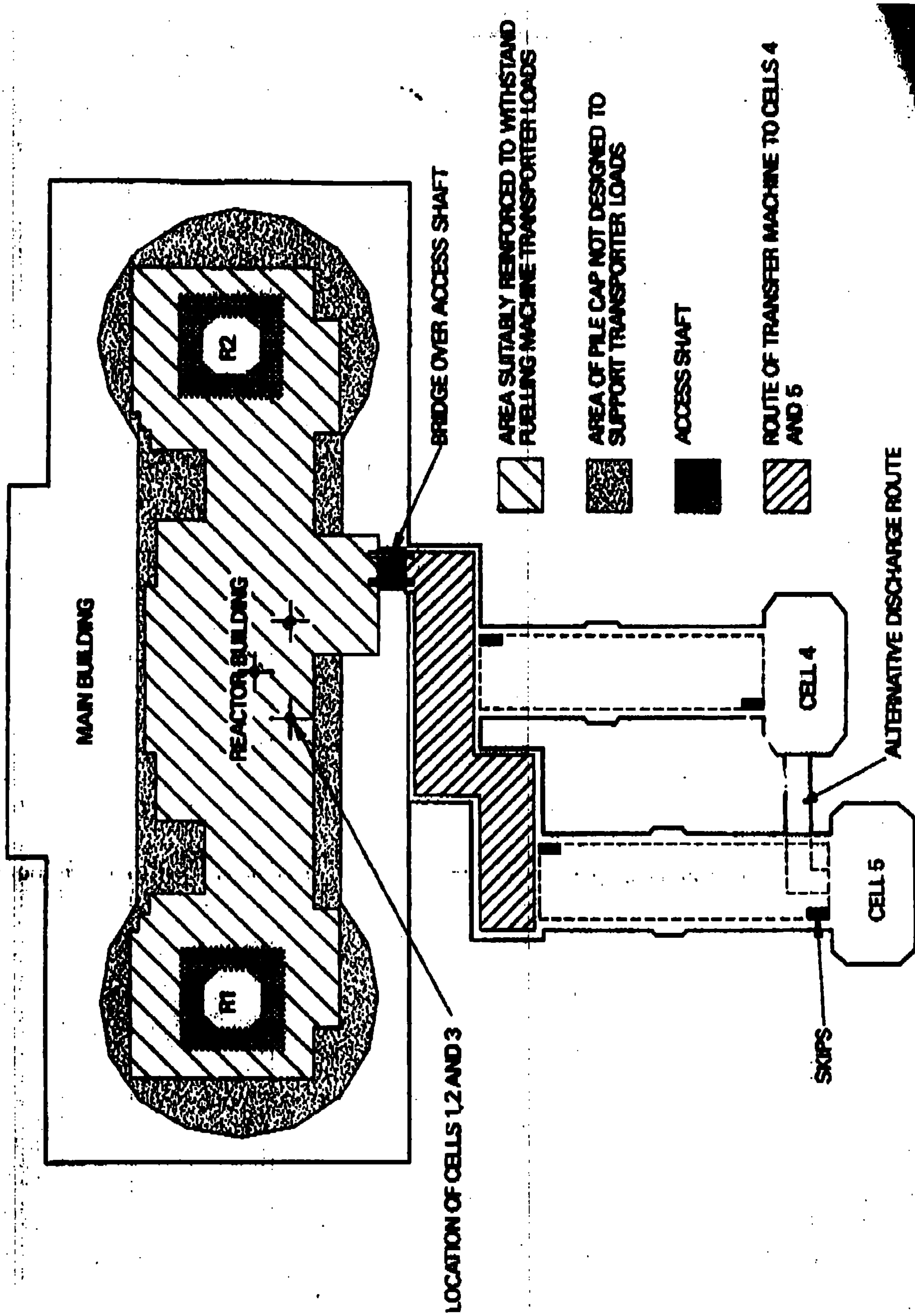

Figure 5 LOCATION OF CELLS ON CHARGE FACE. WYLFA WORKING AREA FOR FUELLING MACHINERY.

these loads. It can therefore be seen that it would be extremely difficult for the transporter/fuelling machine to move to the edge of the building without significant stiffening of the working floor over the chosen route. Civil work/structural modifications to stiffen the floor on an operational reactor were highly undesirable as it was the intention to construct the store whilst the reactors continued in operation. The only option available without structural alterations to the reactor building was to build a bridge across the existing access shaft. One end of the bridge could be supported on the area of pile cap already able to take such loads, and the other end of the bridge could be supported on an extension to the proposed new store, suitably designed to take these loads. In this way, the transporter and store transfer machine could run directly onto the top of the new store (Cell 4).

A fundamental disadvantage with this location was the fact that the original flask handling facility was already located in this position and the new store would therefore have to be located above this facility. The flask handling facility had to remain operational throughout the construction of the store which added to the problem.

Another disadvantage with this location was the fact that the base of the store would have to be located some 13.6m above ground level and this precluded multi-element stacking within the store. A diagram showing the arrangement of Cell 4 is given in Figure 10.

5.2 Outline Description of Wylfa Cells 4 and 5

The dry store is a concrete box 60m long, 11m wide and 4.5m high with walls that are 2m thick. Six rows of twenty-five skips are positioned across the store. Each row of skips is supported on two drive chains which are in turn located on rails supported on concrete plinths running the length of the store. The drive chains penetrate the walls at each end of the store. The chain driving system is located outside the store with appropriate tensioning devices. A traverse mechanism for moving skips from one row to another is located inside the store at each end of the rows of skips.

Each skip comprises a matrix of blind tubes in a 12 x 16 array. The elements radiate heat to the natural convection cooled walls of the tube. The bulk temperature of the area within the store is maintained at a satisfactory temperature by 4 of the 5 heat exchanger units that reject up to 750 KW of heat to the reactor ancilliaries cooling water system.

5.3 Construction and Commissioning

Work commenced on site in September 1976. The initial work was to identify and re-route various existing underground services to the station, eg., cables, radioactive drains, fire mains, etc., in preparation for foundation

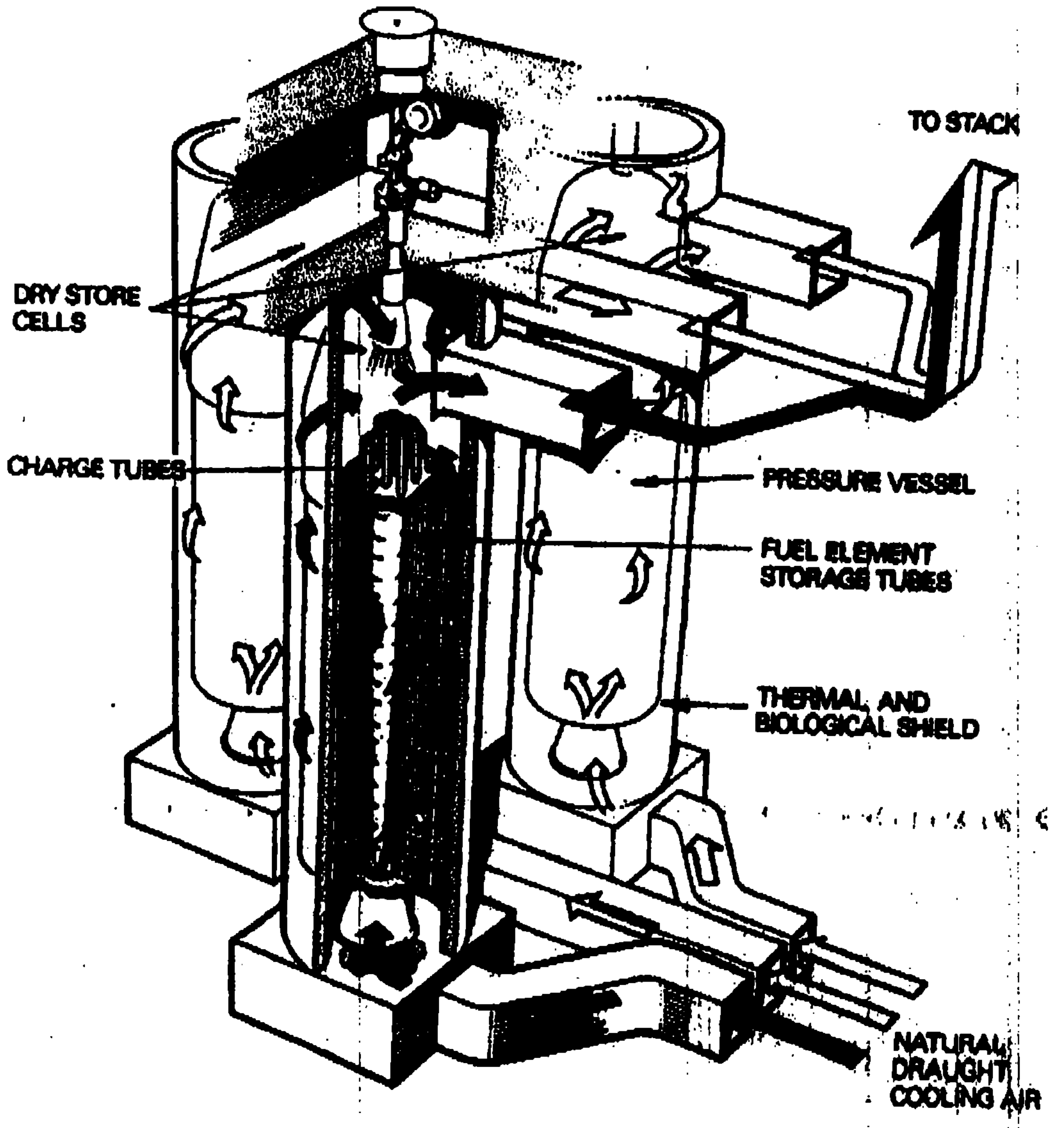

Figure 6 SECTION THROUGH CELL

WYLFA DRY STORE CELLS 1, 2 AND 3
OPERATIONAL EXPERIENCE

1 COMPLETELY PASSIVE COOLING SYSTEM IS INHERENTLY RELIABLE.
2 NEGLIGIBLE MANNING REQUIREMENT WHEN CELLS ARE LOADED.
3 WIND HAS NO DETECTABLE EFFECT ON STORE PERFORMANCE.
4 MATERIALS OF CONSTRUCTION HAVE BEEN DEMONSTRATED TO HAVE ADEQUATE LIFE.
5 NO SIGNIFICANT CONTRIBUTION TO STATION MAN-Sv COMMITMENT.
6 ACTUAL FUEL TEMPERATURES LESS THAN THOSE PREDICTED THEORETICALLY DURING DESIGN PROCESS.
7 IRRADIATED FUEL STORED FOR SIGNIFICANT PERIODS IN PRISTINE CONDITION.
8 NEGLIGIBLE WASTE GENERATION.
9 LICENSING APPROVAL FOR RELOADING INTO REACTOR IF DESIRED.

Figure 7 OPERATIONAL EXPERIENCE

WYLFA DRY STORE CELL 4
BASIC DESIGN CRITERIA

1 AIR TO BE THE CELL ENVIRONMENT FOR THE STORED FUEL.
2 AIR TO BE MAINTAINED AT A SLIGHT DEPRESSION WITH RESPECT TO ATMOSPHERE TO PROVIDE THE SECOND BARRIER OF THE TWO BARRIER CONTAINMENT CONCEPT.
3 MAXIMUM FUEL ELEMENT TEMPERATURE DURING NORMAL OPERATION LESS THAN 150°C.
4 MAXIMUM FUEL ELEMENT TEMPERATURE DURING WORST CREDIBLE FAULT NOT TO EXCEED 200°C.
5 NO CONDENSATION UNDER LOWEST CREDIBLE TEMPERATURES.
6 DURING NORMAL OPERATIONS MOISTURE LEVELS TO BE LESS THAN 50% RELATIVE HUMIDITY.

Figure 8 DESIGN CRITERIA

piling. In parallel with this operation, the civil and plant detail designs were commenced and long lead items of equipment were ordered for manufacture. Throughout the design, construction and manufacturing phases the civil structure and items of plant had to be approved by an independent design assessor, a mandatory requirement of the CEGB's Plant Modification Procedure. Independent inspection of the plant after installation and prior to commissioning was also a requirement. Before commissioning of the plant could commence all of the relevant commissioning documentation had to be approved in a similar manner.

Commissioning of the plant was basically divided into three sections:

1 Transfer machine

2 In-cell equipment

3 Cell cooling/conditioning equipment.

Each section was commissioned independently of the other followed by final integrated system commissioning tests. Before active fuel could be loaded into the store the final safety document and commissioning test results had to be approved by the independent design assessors and the Nuclear Installation Inspectorate of the Health and Safety Executive.

6 OPERATIONAL EXPERIENCE

The first of the two air cooled stores was commissioned for operational use in September 1979 and was filled to capacity (28,992 elements) by September 1981. The time taken to fill the store was dictated by operational requirements of the fuelling complex, ie, simultaneous operation of on-load refuelling of the two reactors, irradiated fuel dispatch in flasks to BNFL for reprocessing and the transfer of irradiated fuel to the store. Experience to date has been very good, bearing in mind the novel design of the plant. Breakdowns have been relatively few since it has been in operation. Two breakdowns of items of plant have occured which involved working on contaminated equipment:

1 Faults on the chute indexing mechanism which occurred on that part of the mechanism within the cell. This involved withdrawing the internal mechanism for repair and modifications.

This has occurred on 4 occasions with varying amounts of irradiated fuel in the store from 2,500 elements to 8,000 elements (early in December 1979, end of January 1980 and twice in March 1980). The contract routine maintenance equipment, ie, shielding and withdrawal equipment designed for routine maintenance of the indexing mechanism was used and during each of the above incidents, radiation doses to operators was minimal 0.01 mSv/hr (1 mr/hr). Also bearing in mind this mechanism is in the most active part of the route, the contamination levels on the mechanism

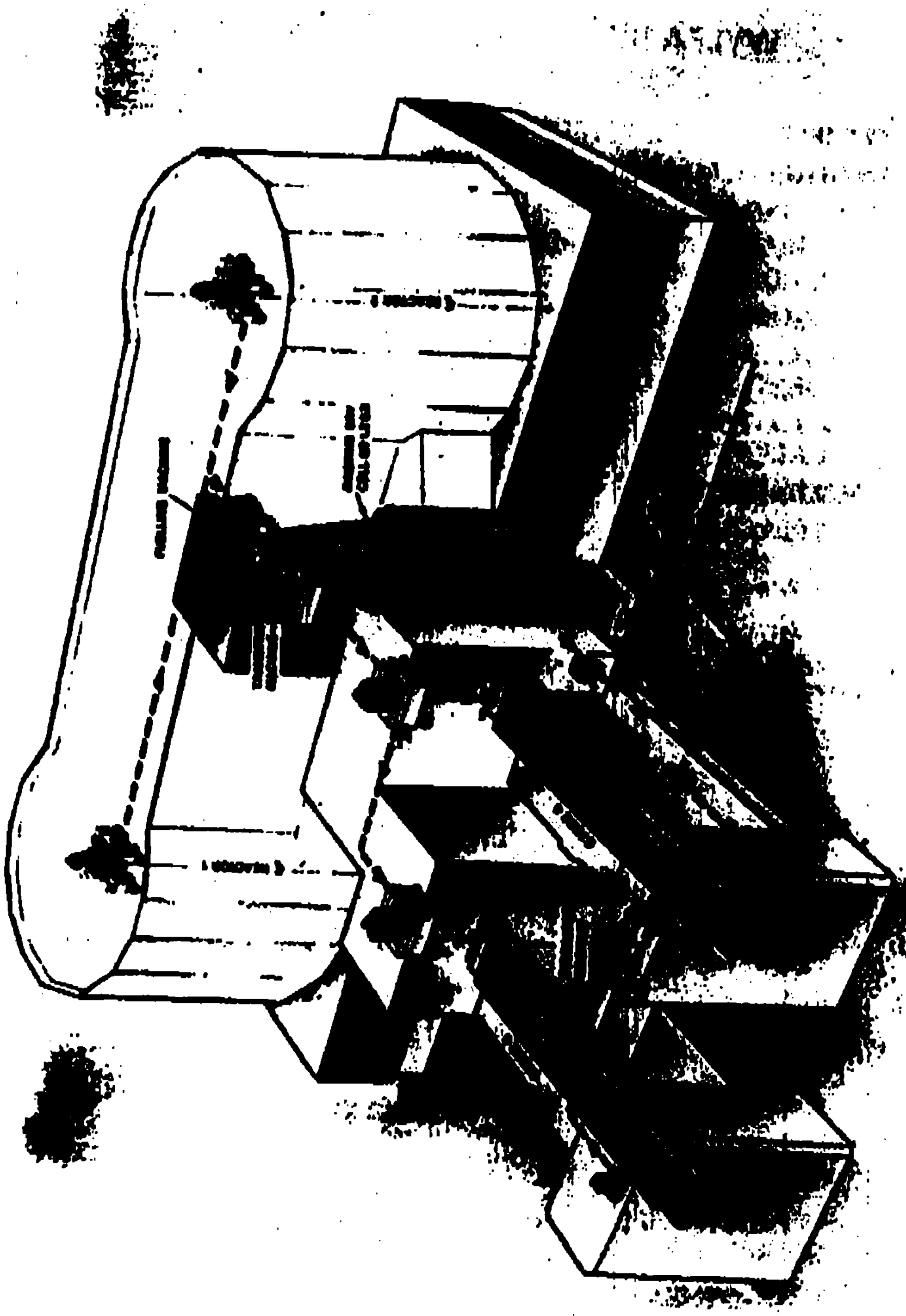

Figure 9 PERSPECTIVE OF CELLS 4 AND 5 SHOWING LOCATIONS WITH RESPECT TO REACTORS

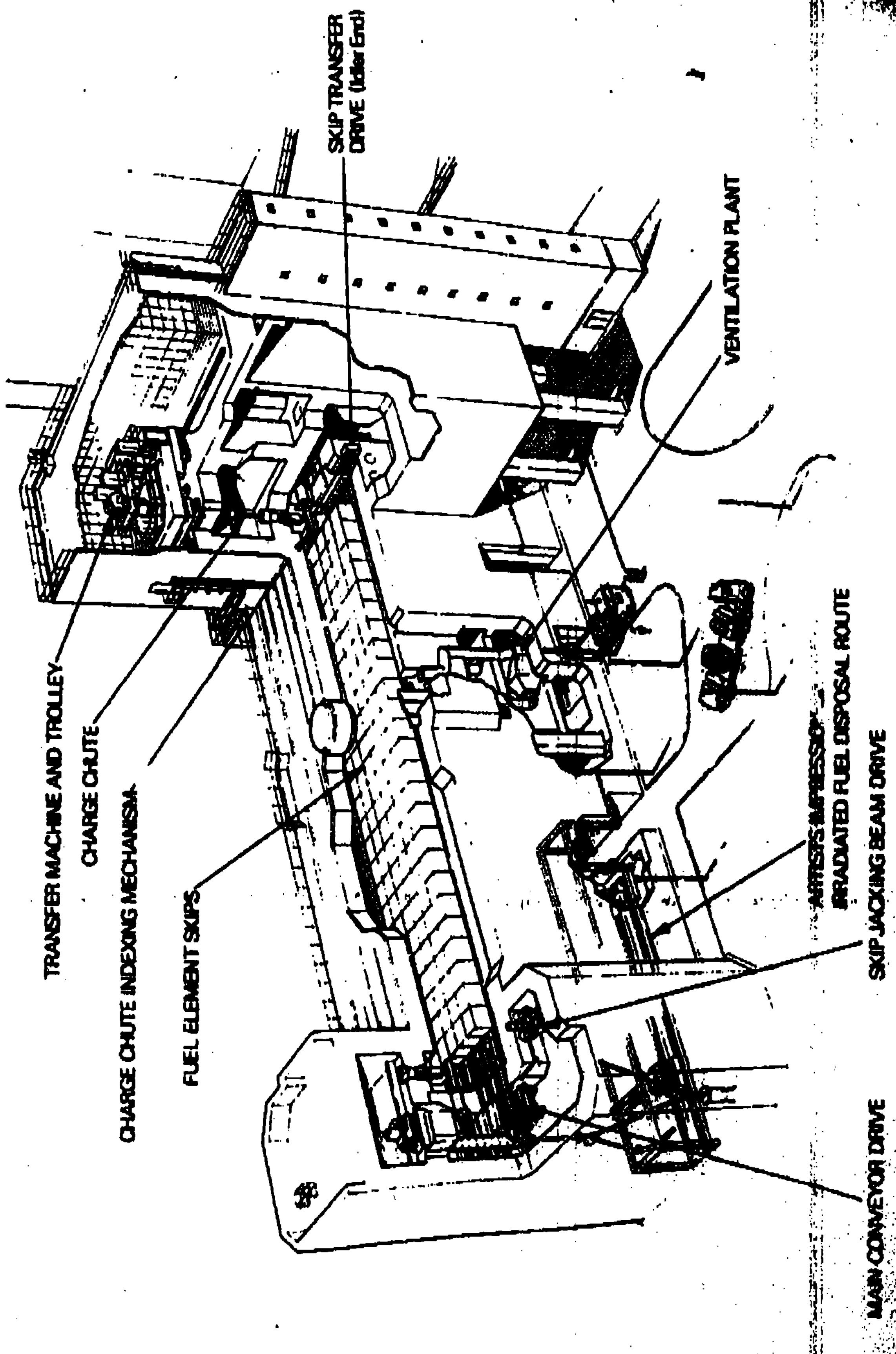

Figure 10 PERSPECTIVE THROUGH CELL 4

were sufficiently low to enable C2 working to be carried out. 37-370 Bq/cm² (10^{-3} to 10^{-2} uc/cm²).

2 The second item of plant breakdown occurred on the tansfer machine fuel element hoist (April 1980). The hoist drive shaft seized with a considerable amount of contaminated rope paid out. Again, radiation levels during the recovery exercise were minimal, 1.0 mSv (100mr/hr) at the through hole of the machine but only less than 0.001 mSv/hr (0.1 mr/hr) to the operator. Contamination levels were low enough to enable C2 working to be carried out during unroping of the hoist and remedial work of the hoist drive.

7 GENERAL OPERATING CONDITIONS

All operational areas of the plant at pile cap are classified as R2 C2, ie., the same as the reactor pile cap. Operational areas such as the switchgear room, pipe room, fan and filter rooms where monitoring of the plant conditions are carried out on a routine basis are uncontrolled zones. The east sprocket room is classified as an R2 C2 area only because access is via the reactor pile cap which is an R2 C2 area. The west sprocket room, which has the same access as the plant room is also an uncontrolled zone. In these areas, the general radiation level from the cell is 0.0002 mSv/hr (0.02 mr/hr).

Activity of the circulating air circuit is very low, typical values of gaseous and particulate activity being less than 0.37 Bs/ml (10^{-5} uc/ml) and less than 0.37 Bq/m³ (10 pc/m³) respectively. Also a typical value of particulate activity being discharged to atmosphere from the continuous exhaust system is less than 0.037mBq/m³ (1 pc/m³) (of the order of background activity level).

Typical environmental conditions within the store (full) are:

Air inlet temperature to heat exchangers	36°C
Air outlet temperature from heat exchangers	32°C
Relative humidity	28%
Cell depression	25m bar below atmospheric
Cooling water flow to heat exchangers	4.5 l/s
Total power requirement for plant	90 KW

(fans 73 KW, exhauster 4.5 KW, dehumidifier 4.5 KW and PLC's 8 KW).

Experience to date with Wylfa Cell 4

1 Activity levels within the store circulatory system and that discharged to atmosphere are at background levels.

2 Radiation levels to operators during normal operation are extremely low 0.0002 mSv/hr (0.02 mr/hr).

3 There is no generation of radioactive slurries, sludges, ion exchange resins, etc, which have to be stored and eventually disposed of. The small capacity combustible

TIME SCHEDULE FOR PLANNING AND CONSTRUCTION OF WYLFA DRY STORES

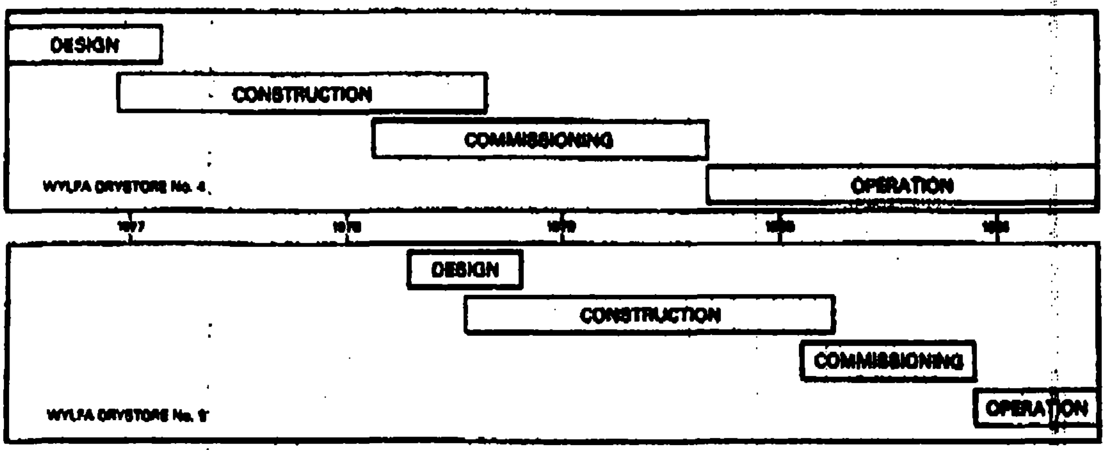

Figure 11   CONSTRUCTION AND COMMISSIONING

WYLFA DRY STORE CELL 4
OPERATIONAL EXPERIENCE

1 ACTIVITY LEVELS WITHIN STORE CIRCULATING SYSTEM ARE AT BACKGROUND LEVEL.

2 RADIATION LEVELS TO OPERATORS DURING NORMAL OPERATION ARE EXTREMELY LOW ~ 0.0002 mSv/h.

3 NEGLIGIBLE WASTE GENERATION.

4 MAINTENANCE REQUIREMENTS MINIMAL.

5 LEVEL OF DEPRESSION GIVES ACCURATE INDICATION OF INTEGRITY OF CONTAINMENT.

Figure 12   OPERATIONAL EXPERIENCE OF CELL 4

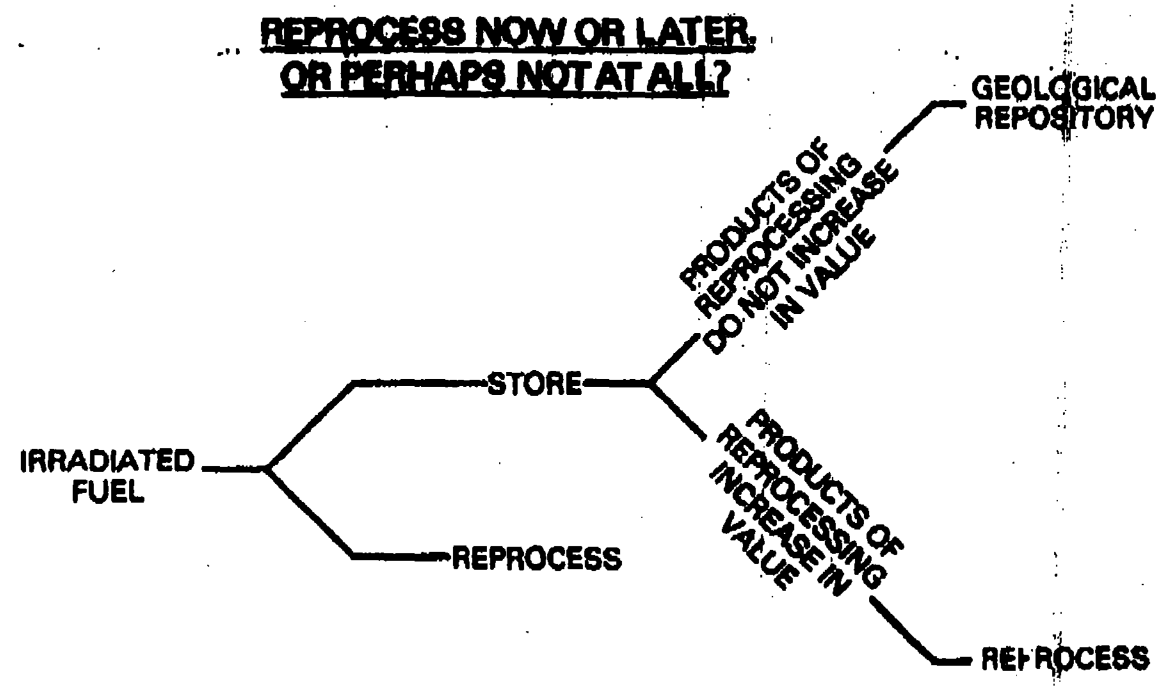

Figure 13 WHAT IS THE SIGNIFICANCE OF [illegible]G ABLE TO STORE IRRADIATED FUEL FOR MEDIUM/LONG PERIODS?

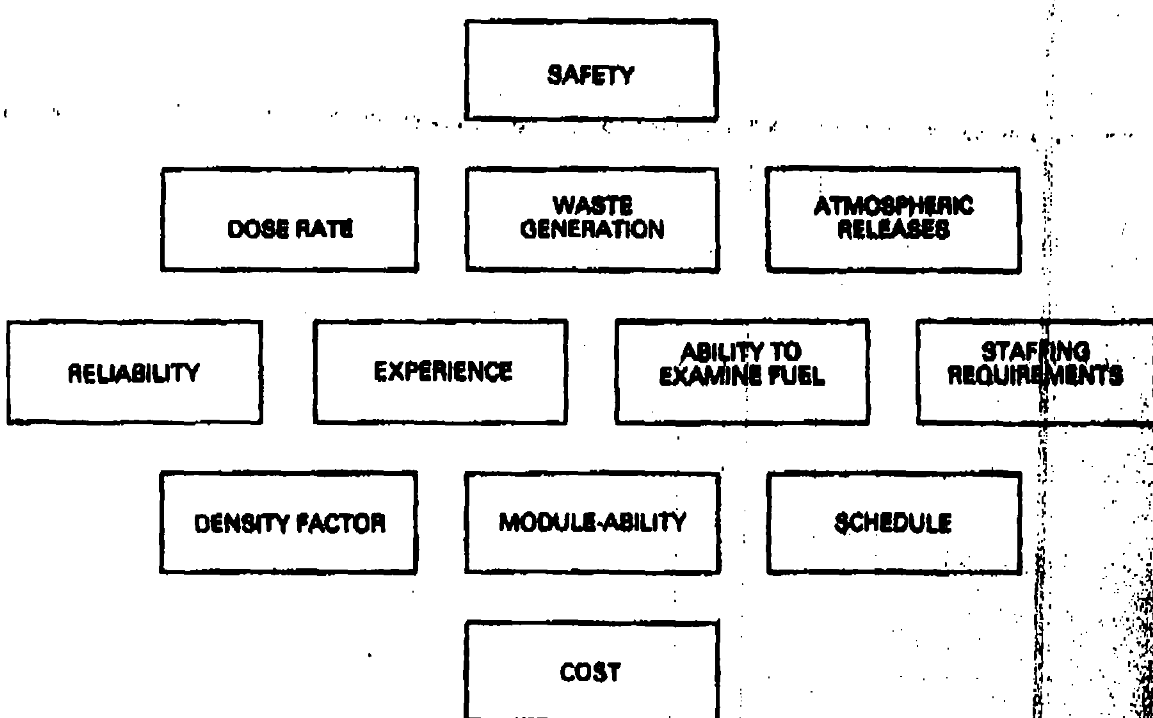

Figure 14 AUTHOR'S VIEWS ON PARAMETERS THAT SHOULD BE USED TO MEASURE ADEQUACY OF THE MANY STORAGE OPTIONS CURRENTLY BEING CONSIDERED THROUGHOUT [illegible]

filters have been in operation since the cell was commissioned and have not yet picked up significant contamination.

4 Radiation levels to personnel during maintenance of the most active part of the plant were 0.01 mSv/hr (1 mr/hr) with correspondingly low contamination levels. Maintenance requirements after the initial 'setting to work' period are minimal.

5 The new store operates at a depression with respect to atmospheric pressure and therefore any leakage is inwards. The level of depression gives accurate and continuous indication of integrity of containment.

6 The storage period in the store is almost indefinite.

8 WHAT IS THE SIGIFICANCE OF BEING ABLE TO STORE IRRADIATED FUEL FOR MEDIUM/LONG PERIODS?

Whilst the design, manufacture and construction of the large air cooled dry stores at Wylfa was being carried out, it was realised in the UK that these principles of dry storage already proven for many years at Wylfa for magnox fuel, could also be applied to irradiated oxide fuel. It was therefore decided at that time to invest very significant time and effort in a development programme to demonstrate feasibility of this proposal.

Since that time, much work has been done and feasibility, cost and schedule are now well established.

The option of long term storage of irradiated fuel allows a more flexible approach to the question of ultimate disposal of the irradiated fuel. In particular, the timing and type of ultimate waste disposal can be optimised in the light of the intrinsic value of the products from the reprocessing cycle and cost of reprocessing itself. The cost of reprocessing may also reduce due to the capability of optimising the rate of throughput of irradiated fuel through the reprocessing cycle which a long term storage capacity allows.

8.1 What Type of Medium/Long Term Store?

As the need to store irradiated fuel for medium/long periods is becoming established, it is necessary to determine what type of storage best suits the need.

The authors have attempted to list the basic parameters that they consider should be used to measure the adequacy of the many storage options currently being considered around the world.

1 Safety-Tolerance of the Design Concept to Meet the Latest Safety Standards

Safety standards to which nuclear installations are designed vary throughout the world. Although the safety standards that were set for established designs are extremely high, the various accident conditions that have to be considered continue to increase in number and severity. It is likely that this will be the trend in the future and it is therefore necessary to consider the mechanism of failure of new designs when the severity of the postulated hazard is increased beyond that dictated by present standards. The desirable goal must be that any failure will occur by a process of gradual degradation rather than in a catastrophic mode.

2 Dose Rate

Ability of the design of the fuel store to meet the necessary functional requirement with the minimum of additions to the station total man-Sv commitment is the objective. With the pond method of fuel storage the water shielding can be by-passed because possible corrosion products on the surface of the pond may 'shine' directly to operators. This is especially true for magnox clad fuel and the problem exists to a lesser degree for any other type of fuel, especially during handling operations.

Utilisation of the dry storage principle enables storage facilities to be designed in which shielding cannot be short-circuited in this way. Although it can be demonstrated that well maintained ponds will keep dose rates down to 0.02 to 0.03 mSv/hr (2 to 3mr/hr) it can also be demonstrated that of the total station man-Sv commitment, the 'back end' of the station is responsible for a high proportion of this operator dose. It must therefore be prudent to consider carefully designs that can reduce this increment to negligible proportions.

3 Reliability

There is very strong preference for passive cooling systems that rely upon the natural heat transfer methods of convection, radiation and conduction for their safe operation. Use of an air environment for the irradiated fuel, maintained at a slight negative pressure, allows the use of containment that although nominally leak-tight, does not need absolute standards of leak-tightness to maintain established safety standards criteria. Such a design must be less vulnerable to regulatory trends.

4 Waste Generation

Unnecessary generation of radioactive contaminated material is both expensive and undesirable. The various systems must be carefully evaluated and preference given to the selection of system and processes that generate the very minimum of radioactive waste and contaminated materials. This evaluation must include examination of water treatment facilities, storage and eventual disposal of radioactive resins and sludges, decontamination and the possible need to can fuel assemblies.

5 **Density Factor**

In order to obtain the best utilisation of land, a high density factor is desirable in a fuel store. When comparing the density factors for different methods of storage it is obviously necessary to include all the support systems for the system being considered together with any waste storage requirements that may be necessary. Very often density factor comparisons are made purely on a capacity per storage area basis rather than a capacity 'per complex' basis.

6 **Experience**

It cannot be denied that to date there is far greater experience in the pond system of irradiated fuel storage than any other form of storage. However, it is necessary to take into account the fact that the early design of pond installations took place before the design parameters for irradiated fuel storage facilities became so exacting. It is not suggested for one moment that pond-type installations cannot be built to the necessary safety standards but rather that when considered against the latest design specifications, dry storage is likely to give a better overall optimisation of requirements.

7 **Staffing**

It has been demonstrated in Britain that the minimum number of operators for a dry storage system is typically one third of the number required for a similar capacity pond installation.

8 **Fuel Examination**

World-wide there is more experience of storing irradiated fuel for short and medium periods in water than in any other type of storage system. For the long term storage of fuel, however, there is little experience with any system of storage. It is necessary therefore to examine the design principles most carefully and to be satisfied that, theoretically, the design should be adequate.

However, as the ageing process is most difficult to simulate, it is considered necessary that whichever type of storage system is employed, means should be provided in order that the fuel may be examined with a routine and frequency to be determined by experience, in order to confirm that no long term degradation trends are present. Dry storage enables easy examination to take place without significant increases in total dose rate to the operator.

9 **Radioactive Release**

The release of contaminated gas/gaseous fission products to the atmosphere is obviously undesirable.

10 **'Module-Ability'**

The ease with which further storage modules can be added is a distinct advantage. Capacity of storage systems can be tailored to closely follow the requirements of an operatonal site.

11 **Schedule**

The programme for design, manufacture and construction of the first large air-cooled dry store at Wylfa has demonstrated an overall time-scale of three years for this type of installation. The second store to a similar design has been completed in two years. This performance is considered to be ample evidence that dry storage installations for this type and other types of fuel and radioactive waste can be completed within three years. The modular form of construction also enables a phased commissioning of equipment.

12 **Costs**

When carrying out cost comparisons for different systems, it is essential that the systems being considered are designed against the same functional specifications. It is also necessary to include all costs associated with that system in the comparison. For example, if a certain storage system requires the fuel to be canned then the cost of the cans, the cost of the canning facility (or a proportion of the facility if it is common to several stores) and the cost of the eventual disposal of the cans must be included. Similarly, when a water treatment plant is involved, in addition to the cost of the treatment plant, it is also necessary to include the cost of storage and disposal of the spent filter resins, etc. The fact that it is difficult to obtain these more diffuse costs is no excuse for not including them in any comparison.

ACKNOWLEDGEMENTS

The authors wish to thank the Central Electricity Generating Board and GEC Energy Systems Ltd for permission to publish this paper, and the Wylfa Power Station staff for information on operating experience.

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DOCUMENT NO. AND TYPE	SUBJECT/TITLE	DATE	RESTRICTION
002. report	re North Korea (6 pages)	07/00/1994	P1/b(1)

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North Korea, August 1994 [9]

2009-0528-F
kc1571

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cc: Aoki

United States Department of State

Washington, D.C. 20520

July 25, 1994

TO: SSK - Mr. Poneman

FROM: EAP/K - David E. Brown

SUBJECT: Planning for North Korea Energy Options Survey.

SUMMARY. The International Energy Agency (IEA) has begun assembling available information to support the survey of North Korean energy options that we proposed to the DPRK on July 8. A senior IEA official on July 22 indicated that the Agency could complete a survey of appropriate scope by December, assuming that the DPRK issues an invitation within the next month. Its value and impact will depend largely on the extent of DPRK engagement. The US Nuclear Disarmament Fund (NDF) could cover most or perhaps all of the relatively modest cost (under $200,000) of the survey. END SUMMARY.

Linda Gallini and Steve Saboe of PM, Fritz Maerkle of EB, and I met on July 22 with Bob Skinner, the IEA official who would organize and lead its proposed study of the DPRK's energy policy options. Skinner directs the IEA's Long-Term Policy Office. IEA staff have designed and carried out similar work in a number of Eastern European countries and USSR successor states.

The meeting reconfirmed that the IEA work would be designed to help North Korea to identify practical ways to increase the efficiency of its energy production, distribution and end-use across all fuels and technologies, taking its present command economic system as a given. An implicit purpose would be to show the DPRK that its scarce resources can be more productively invested in conventional energy development than in nuclear power.

We discussed the IEA's requirements for DPRK contacts and preparatory information for the survey and financing. Skinner said that the IEA will need an invitation from the DPRK's energy minister or equivalent before it can begin a study. To focus its field work, the IEA intends to assemble readily available information from China, Russia, the UNDP, and the Nautilus Institute and other US sources. It will seek on the ground support from IEA member countries with embassies in Pyongyang, e.g. Switzerland and Sweden.

Skinner expects the IEA study would require two trips to North Korea. The first would be a brief visit by Bob (a Canadian) the IEA's South Korea "desk officer" (an Australian), and an interpreter to establish contacts and gauge North Korean willingness to welcome a larger mission. Skinner and Peter Hayes of Nautilus Institute are discussing Hayes' participation as well. Parameters of the second, longer trip would be set by the results of the first visit.

Steve Saboe said that the NDF could fund expenses of the study, including travel by non-Americans. We asked the IEA to seek additional funding from other member states, to give the work a multilateral flavor. Saboe emphasized the need for close IEA cooperation with NDF budgeting and documentation requirements, so we can prepare a proposal which could withstand the required Congressional review. Saboe will meet with Skinner in Paris late in July to further explain NDF procedural requirements.

cc: SSK - A/S Gallucci
EAP - DAS Hubbard
PM/RNP - JWit
PM/NE - LGallini
NDF - SSaboe
EB/IEP - FMaerkle/EDesantis
DOE/IE - RPrice/DPumphrey

DONE

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DUE: 19 SEP

- [x] Prepare Memo For Lake/Berger
- [ ] Prepare Memo For Podesta
- [ ] Prepare Memo ______ to ______
- [ ] Appropriate Action
- [ ] Prepare Memo For Itoh

CONCURRENCES/COMMENTS* PHONE* to action officer at ext. ______

Concur	FYI		Concur	FYI		Concur	FYI	
	X	Andreasen			Gottemoeller			Ross
		Andricos			Hahn			Rossin
		Aoki			Halperin	X		Roth
		Atkins			Harris			Satterfield
		Beers			Indyk			Schifter
	X	Bell			Jenson-Moran			Schwartz
		Beyrle			Jones			Seaton
		Blakeman			Kerrick			Simon
		Bradley			Kreczko			Sonenshins
		Breeland	X		Kristoff			Spalter
		Burns			Kyle			Steinberg
		Clarke			Laipson			Stephens
		Claussen			Leary			Suettinger
		Danvers			LeBourgeois			Tenet
		Darragh			Mislock			Van Tassel
		DeShazer			Mitchell			Vershbow
		Fauver			Murase			Wales
		Feinberg	X		Poneman			Walsh
		Forsythe			Punke			Whyman
		Fried			Reed			Witkowsky
		Froman			Rice		X	GRAY
		Genton			Rocha			

INFORMATION

- [ ] Itoh
- [ ] Lake
- [x] Sens
- [ ] Berger
- [x] Soderberg
- [x] Wolin
- [ ] Exec Sec Desk
- [ ] Records Mgmt.

COMMENTS

Prepare response by early next week.

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